MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EMF3066 – ANTENNA AND PROPAGATION

(TE & MCE)

5 MARCH 2016
9:00 A.M- 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 5 Questions only.
2. Attempt **ALL FIVE** questions. Each question carry equal marks and the distribution of the marks for each question are given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) The electric and magnetic fields surrounding a Hertzian dipole (also referred to as short dipole or infinitesimal dipole) are given below. The dipole is placed at the center (origin) directed at the z-axis. I_m is the current on the dipole, L is the length of the dipole, β is the phase constant, η is the free space impedance, ω is the radial frequency, ε is the permittivity of free space and (r, θ, ϕ) is the spherical coordinate system.

$$H_r = H_\theta = E_\phi = 0$$

$$H_\phi = \frac{I_m L \sin\theta e^{-j\beta r}}{4\pi}\left[\frac{j\beta}{r} + \frac{1}{r^2}\right]$$

$$E_r = \frac{I_m L \cos\theta e^{-j\beta r}}{2\pi}\left[\frac{\eta}{r^2} + \frac{1}{j\omega\varepsilon r^3}\right]$$

$$E_\theta = \frac{I_m L \sin\theta e^{-j\beta r}}{4\pi}\left[\frac{j\omega\mu}{r} + \frac{\eta}{r^2} + \frac{1}{j\omega\varepsilon r^3}\right]$$

(i) Write the approximate expressions for the far electric and magnetic fields of this short dipole (assuming $\beta r >> 1$).

[3 marks]

(ii) By using the Poynting theorem, determine the expression for average power density at the far field of the short dipole.

[7 marks]

(b) Give the definition of the following terms as applied to antennas:

(i) Half-power beamwidth
(ii) Directivity
(iii) Gain
(iv) Radiation intensity
(v) Radiation resistance

[10 marks]

Continued...

Question 2

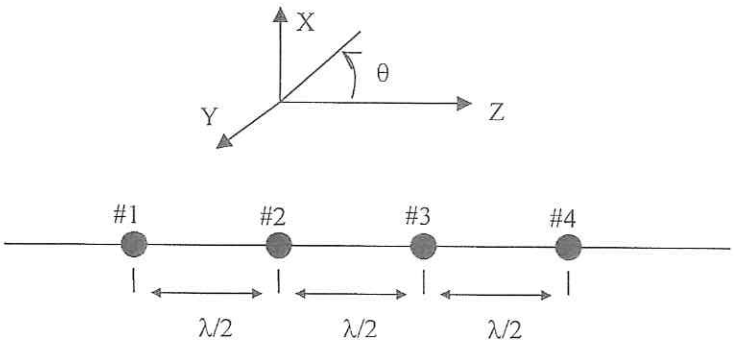

Figure Q2

An array is formed with four isotropic elements spaced at half-wavelength apart, as shown in Figure Q2 above. The elements are placed along the Z-axis. The elements have a progressive phase shift (α) between them. All the elements have equal excitation amplitude (or power).

(a) Starting from the general expression for array factor, show that the normalized array factor for this four element array is $\cos\left(\frac{1}{2}\psi\right)\cos(\psi)$, where $\psi = \pi\cos\theta + \alpha$.

[8 marks]

(b) Evaluate the progressive phase shift (α) that is required, if the peak of the array factor is to be directed at $\theta = 45°$. (In other words, beam is squinted at 45°.)

[12 marks]

Question 3

(a) Discuss the differences and similarities between microstrip patch, horn, dipole and helical antennas, in terms of their radiation pattern, gain and polarization.

[10 marks]

(b) With the help of a diagram, explain the construction and operation of a Yagi-Uda antenna.

[10 marks]

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Question 4

(a) In a free-space propagation of radio wave, state the propagation mechanisms that can affect it.

[5 marks]

(b) Explain the sky wave propagation mechanism.

[10 marks]

(c) Given that a transmitting antenna has a gain of 50 dBi and radiates a power of 15 W at a frequency of 8 GHz. Find the received power at a distance of 20 km if similar antenna is used as receiving antenna.

[5 marks]

Question 5

(a) With the aid of a suitable diagram, derive the monostatic radar equation for a point scatterer. Explain all the terms used in the derivation.

[12 marks]

(b) C-band radar has the following parameters:

Peak transmit power, $P_t = 1.5$ MW,
Operating frequency, $f_o = 5.6$ GHz,
Antenna gain, $G = 45$ dB,
Effective temperature, $T_e = 290$ K and
Pulse width, $\tau = 0.2$ μs.

If the radar's minimum SNR is 20 dB and assuming that the target cross section, σ is 0.1 m^2 with a system loss of 3 dB, determine the maximum range.
[Note: Boltzmann's constant, $k_B = 1.38 \times 10^{-23}$ J/K]

[8 marks]

Continued...

Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s
Electron rest mass	m	9.11×10^{-31} kg
Effective electron mass	m_e	$0.068m$
Effective hole mass	m_h	$0.56m$

End of paper.